Mini-Workshop on Neutrino Theory

Monday, September 21, 2020 - Wednesday, September 23, 2020

Book of Abstracts

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Heavy Neutral Leptons as a Portal to the Dark Sector

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The connection between the Standard Model and a dark sector may take place in a variety of way, most generically through portal couplings. In this talk, I discuss an example where exploiting the neutrino portal as a stepping stone to the dark sector opens up a set of unexplored experimental signatures at neutrino, e^+e^- colliders, and kaon experiments. I will focus on models with a new local $U(1)'$ symmetry, with applications to the MiniBooNE anomaly and the muon g-2.

Contributed 06 / 19

The nucleon axial form factor in chiral perturbation theory

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The nucleon axial form factor is not only a fundamental property for the understanding of hadron structure but also a key ingredient of neutrino-nucleon cross sections, whose precise knowledge is required for the analysis of neutrino oscillations. We have calculated this form factor at low momentum transfers in Baryon Chiral Effective Theory, using the extended on mass shell renormalisation scheme, and including the Delta(1232) as an explicit degree of freedom. To assess the convergence of the perturbative expansion and estimate truncation errors, the study is performed at leading and next to leading one-loop orders. We fit recent lattice QCD results to determine the unknown low energy constants of the theory and extract the axial charge and radius.

Contributed 02 / 20

Probing the Nature of Neutrinos with a New Force

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We discuss the possibility to distinguish between Dirac and Majorana neutrinos in the context of the minimal gauge theory for neutrino masses, the B-L gauge extension of the Standard Model. We revisit the possibility to observe lepton number violation at the Large Hadron Collider and point out the importance of the decays of the new gauge boson to discriminate between the existence of Dirac or Majorana neutrinos.

Contributed 12 / 21

Inference offers a metric to constrain dynamical models of neutrino flavor transformation

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The multi-messenger astrophysics of compact objects presents diverse environments where neutrino flavor transformation may be important for nucleosynthesis and a detected neutrino signal. Development of efficient techniques for surveying flavor evolution solution spaces, which complement existing computational tools, could leverage progress in this field. To this end we explore statistical data assimilation (SDA) to identify solutions to a small-scale model of neutrino flavor transformation. SDA is a machine learning formula wherein a dynamical model is assumed to generate measured quantities. We use an optimization formulation of SDA wherein a cost function is extremized via the variational method. Regions of state space wherein the procedure identifies the global minimum correspond to parameter regimes in which a model solution can exist. The study seeks to infer flavor transformation histories of two mono-energetic neutrino beams coherently interacting with each other and with a matter background. We require that the solution be consistent with flavor fluxes at detection, and with constraints placed on flavor at locations along their trajectories, including the Mikheyev-Smirnov-Wolfenstein resonances. Results intimate the promise of this "variational annealing" methodology to efficiently probe fundamental questions that traditional simulation codes render difficult to access.

Contributed 04 / 23

Multi-angle quantum many-body collective neutrino-flavor oscillations

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In core-collapse supernovae and merging of neutron stars a very large number of neutrinos are produced and impact the subsequent evolution of these compact objects. In this work I study neutrino flavor oscillations under the influence of the self-energy induced by neutrino-neutrino interactions, called collective oscillations. I study the flavor evolution of a dense neutrino gas by considering vacuum contributions, matter effects and neutrino self-interactions. Assuming a system of two flavors in a uniform matter background, the time evolution of the many-body system in discretized momentum space is computed. The multi-angle neutrino-neutrino interactions are treated exactly and compared to both the single-angle and mean field approximations. The many body treatment reveals collective oscillations and non-negligible entanglement entropy which results in rapid flavor equilibration, not found in the mean field treatment. This is just a first step, and more work will be required in the future to tackle larger and larger systems. The problem, as described here, could be easily implemented and benefit from emerging technologies like quantum computing. For more details, the interested reader can access the article at Phys. Rev. C 101, 065805 (2020).

Contributed 04 / 24

Collective neutrino oscillations: Status and prospects

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Collective neutrino oscillations are predicted to occur in supernovae, neutron-star mergers, and potentially the early universe, with ramifications for the evolution and observables of these environments. This talk will survey our current understanding of the phenomenology, which has recently seen transformative developments. It will also overview the open questions that are poised to be answered in the coming years, and will emphasize the significance of these questions for particle physics and multi-messenger astronomy.

Contributed 02 / **25**

The fate of hints: are there tensions in the global three-neutrino data?

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After the new data presented at the Neutrino2020 conference, the global picture of three-neutrino mixing has changed significantly: the hint for Normal Mass Ordering has decreased, and leptonic CP conservation is allowed within less than 1 sigma.
In this talk, I will scrutinize the origin and internal consistency of the global results. The latter allows to quantitatively assess whether three-neutrino mixing can accommodate all data, or if there are hints for further new physics.

Contributed 12 / **26**

A neutrino window to microscopic black holes at IceCube

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If large enough extra dimensions exist, the fundamental gravity scale may be as low as a few TeV to allow for the production of microscopic black holes in collisions of high energy particles. Cosmogenic neutrinos may reach the energy up to tens of EeV, which translates to the center of mass energy of more than 100TeV in neutrino-nucleon scattering, rendering the next generation of neutrino telescopes the ideal places to test large extra dimensions. We identify a number of unique signatures of microscopic black holes as they would appear in future neutrino observatories such as IceCube-Gen2 and the Pacific Ocean Neutrino Explorer, including new event topologies, energy distributions, and unusual ratios of hadronic-to-electronic energy deposition.

Contributed 04 / **27**

Presupernova neutrinos: directional sensitivity and prospects for progenitor identification

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We explore the potential of current and future liquid scintillator neutrino detectors of $\mathcal{O}(10)$ kt mass to localize a pre-supernova neutrino signal in the sky. In the hours preceding the core collapse of a nearby star (at distance D less than or equal to 1 kpc), tens to hundreds of inverse beta decay events will be recorded, and their reconstructed topology in the detector can be used to estimate the direction to the star. Although the directionality of inverse beta decay is weak (∼8% forward-backward asymmetry for currently available liquid scintillators), we find that for a fiducial signal of 200 events (which is realistic for Betelgeuse), a positional error of $\sim 60^\circ$ can be achieved, resulting in the possibility to narrow the list of potential stellar candidates to less than ten, typically. For a configuration with improved forward-backward asymmetry (∼40%, as expected for a lithium-loaded liquid scintillator), the angular sensitivity improves to $\sim 15^\circ$, and – when a distance upper limit is obtained from the overall event rate – it is in principle possible to uniquely identify the progenitor star. Any localization information accompanying an early supernova alert will be useful to multi-messenger observations and to particle physics tests using collapsing stars.

Contributed 02 / 28

A comprehensive EFT global fit in the neutrino experiments

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I will talk about how to systematically study the physics beyond the standard model (BSM) in the neutrino oscillation experiments within the standard model Effective Field Theory (SMEFT) framework. In this way, the analysis of the data can capture large classes of models, where the new degrees of freedom have masses well above the relevant energy for the experiment. Moreover, it allows to compare several experiments in a unified framework and in a systematic way. The approach will be applied to several short- and long baseline neutrino experiments. I will show the results of these EFT searches at the Daya Bay and RENO experiments as well as FASERnu.

Contributed 02 / 30

Decaying neutrinos from a galactic supernova

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A core-collapse supernova (SN) can act as the perfect laboratory to probe fundamental neutrino physics. For example, a future galactic SN will present us with a naturally long baseline to probe new channels of neutrino decay. In this talk, I will discuss the impact of two-body decays of neutrinos on the neutronization burst of a core-collapse SN. Upcoming neutrino experiments like DUNE and Hyper-Kamiokande (HK) can easily detect neutrinos from the burst phase, and impose some of the strongest bounds on such decay channels. Furthermore, a combination of data from DUNE and HK can also distinguish between decaying Dirac neutrinos and decaying Majorana neutrinos.

Contributed 06 / **32**

New Neutrino Interactions and Direct-Detection Experiments

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We find that a magnetic transition dipole moment between tau and sterile neutrinos can account for the XENON1T excess events. Unlike the ordinary neutrino dipole moment, the introduction of the new sterile mass scale allows for astrophysical bounds to be suppressed. Interestingly, the best-fit regions that are compatible with the SN1987A imply either boron-8 or CNO neutrinos as the source flux. We find that sterile neutrinos of either ~ 260 keV or in the ~(500 - 800) keV mass range are capable of evading astrophysical constraints while being able to successfully explain the XENON1T event rate. The sterile neutrino in the best fit parameter space could have significant effects on big bang nucleosynthesis (BBN) and Cosmic microwave background (CMB) depending on the reheat temperature of the Universe.

Contributed 08 / **33**

FASERnu

Author: Felix Kling[1]

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The recently approved FASERnu detector is the first neutrino experiment at the LHC. It will detect over thousands of neutrino interactions during the upcoming Run 3 of the LHC, with typical neutrino energies of a TeV. It will measure neutrino cross sections at energies where they are currently unconstrained and open a new window on physics beyond the standard model. As the first of its kind, FASERnu also paves the way for a high energy neutrino frontier program during the HL-LHC era, with higher luminosities and possibly larger detectors. I will discuss theoretical challenges and requirements as well as BSM physics opportunities, and look forward to many great contributions from the theory frontier community.

Contributed 04 / **34**

Luminous Solar Neutrinos

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Inelastic up-scattering of solar neutrinos during their passage through the earth can yield a flux of unstable right-handed neutrinos (RHνs) provided their mass is relatively light ($m < 20$ MeV). These same particles can decay inside terrestrial detectors, producing visible signatures. For example if the up-scattering is mediated by a transition dipole operator the RHν can deposit a $\sim$ few MeV photon inside the detector. Contrary to naive expectations, over a wide range of parameter space the rate is relatively insensitive to the decay length of the RHν, and can yield detectable signal rates orders of magnitude larger than direct detection via elastic scattering.

Contributed 10 / **35**

New data on neutrino and electron qusielastic scattering.

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Current and future generation neutrino oscillation experiments aim towards a high-precision measurement of the oscillation parameters and that requires an unprecedented
understanding of neutrino-nucleus scattering. Charged-current quasi-elastic (CCQE) scattering
is the process in which the neutrino produces a charged lepton and removes
a single intact nucleon from the nucleus without producing any additional particles.
For existing and forthcoming accelerator−based neutrino experiments, CCQE interactions are either the dominant process or part of the signal.
MicroBooNE is the first liquid argon time projection chamber (LArTPC) commissioned as part of the Short Baseline Neutrino (SBN)
program at Fermilab and its excellent particle reconstruction capabilities allow the detection of neutrino interactions using exclusive final states,
which will play a crucial role in the success of future kiloton LArTPC detectors such as DUNE.
This talk will present the first measurement on argon of exclusive ν_μ CCQE−like flux integrated total and differential cros sections using single proton knock−out interactions recorded by the MicroBooNE LArTPC detector with 4π acceptance and a 300 MeV/c proton threshold.

Contributed 10 / **36**

Neutrino-deuteron scattering in a multipole decomposition framework

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Chiral effective field theory (EFT) provides nuclear interactions as well as electroweak currents constructed in a rigorous framework that allows systematic improvement and uncertainty quantification. Multipole decomposition of the chiral EFT current operators is an essential first step in calculating quasielastic neutrino cross sections using several state-of-the-art methods in nuclear structure theory that employ harmonic-oscillator-basis representation of the nuclear Hamiltonian. I will present our recent calculation of neutrino-induced dissociation of the deuteron at energies from threshold up to 150 MeV by employing chiral EFT potentials and currents in a multipole decomposition framework. Estimates of uncertainties due to nuclear structure and nucleon axial form factor will be discussed. Furthermore, by matching our low-energy chiral EFT results to those of pionless

EFT, we provide new constraints for the counterterm $L_{1,A}$ that parameterizes the strength of the axial two-body current in this theory. Ongoing efforts to extend a similar approach to medium-mass nuclei will be discussed.

Contributed 08 / **37**

Light Extended Neutrino Sectors: Foundations and Phenomenology

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The existence of light sterile neutrinos / heavy neutral leptons below the electroweak scale is of great interest from the points of view of both theory and experiments. We will discuss some theoretical motivations for the existence of such light states in extended frameworks as well as the wide variety of phenomenology that they can give rise to.

Contributed 10 / **39**

Constraints on light vector mediators through COHERENT data

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The observation of coherent elastic neutrino-nucleus scattering (CEνNS) performed, in 2017 with cesium iodide and in 2020 with liquid argon by the COHERENT experiment unlocked an innovative and powerful tool to study many and diverse physical phenomena.
CEνNS is a neutral current process induced by the exchange of a Z boson. It thus represents also a sensitive probe for non-standard interactions that are not included in the SM, induced by yet to be discovered neutral vector bosons, particularly if they are light.
We present new constraints on three different models, the so-called universal, B − L and Lμ − Lτ models, involving a yet to be observed light vector Z' mediator, by exploiting the data recently released by the COHERENT Collaboration. We compare the results obtained from a combination of the cesium-iodide and argon data sets with the limits derived from searches in fixed target, accelerator, solar neutrino, and reactor CEνNS experiments, and with the parameter region that could explain the anomalous magnetic moment of the muon. We show that for the universal and the B − L models, the COHERENT data allow us to put stringent limits in the light vector mediator mass, and coupling, parameter space.

Contributed 10 / 40

Connecting QCD to neutrino nucleus scattering

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The energy spectrum of neutrinos at DUNE is peaked in the few GeV region, where quantifying nuclear model uncertainties arising from nonperturbative quantum chromodyanmics (QCD) effects is particularly challenging. A coherent set of theoretical frameworks is required to describe neutrino interactions with nuclei with the level of accuracy needed for the success of DUNE and other precision neutrino oscillation experiments. We envision developments in lattice and perturbative QCD, nuclear effective field theory, and many-body methods that will be incorporated in neutrino event generators to significantly improve the accuracy of neutrino event reconstruction. I will discuss strategies for interfacing between these frameworks and constructing a pipeline for robustly connecting the neutrino-nucleus cross-sections relevant for neutrino-oscillation experiments to QCD.

Contributed 02 / 41

Issues Related to Matter Effect in DUNE

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Due to its long baseline, DUNE provides an excellent avenue to probe Earth's matter effect and associated degeneracies. We study in detail the performance of DUNE to validate matter oscillation by excluding the vacuum scenario. Whatever be the values of oscillation parameters, we find that DUNE can feel Earth's matter at more than 2σ confidence level. The relative 1σ precision in the measurement of line-averaged constant Earth matter density ($\rho_{\rm avg}$) for maximal CP-violating choices of $\delta_{\rm CP}$ is around 10 to 15% depending on the choice of neutrino mass ordering. If the CP phase turns out to be around -90 or 90, DUNE can measure $\rho_{\rm avg}$ with a precision better than other atmospheric and long-baseline experiments. We also observe new interesting degeneracies among $\rho_{\rm avg}$-$\delta_{\rm CP}$-θ_{23}. A detailed understanding of these degeneracies is essential to correctly assess the outcome of DUNE.

Contributed 12 / 42

Dark Matter Direct(ional) Detection at Neutrino Experiments

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I will show that, via dedicated selection triggers for track signatures, dark matter with per-nucleon scattering cross sections above 10^-28 cm^2 can be discovered at liquid scintillator neutrino detectors such as BOREXINO, SNO+, and JUNO. Thanks to the large fluxes allowed, masses well beyond the Planck mass can be probed. The tracks observed would also directly reconstruct the dark matter velocity distribution, hence determine the dispersion speed, escape speed, and velocity anisotropies of the Galactic halo.

Contributed 02 / 44

Measuring CP-violation with Sub-GeV Atmospheric Neutrinos

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Liquid Argon TPC (LarTPC) detectors have a unique capability in measuring low energy neutrino signals. In this work, we study the DUNE sensitivity to the CP-violation phase using sub-GeV atmospheric neutrinos. LarTPCs would reconstruct with high accuracy the track and the energy of low-energy charged particles, allowing to infer the energy and direction of sub-GeV neutrinos with unprecedented precision. Combining the sensitivity of events with 0,1 and 2 observable protons in the final state, the results indicate that DUNE would be able to exclude several delta_CP values at more than 3\sigma of CL using only atmospheric neutrinos.

Contributed 04 / 46

neutrino flux from dark matter annihilation and decay

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Indirect searches for signatures of corpuscular dark matter have been performed using all cosmic messengers: gamma rays, cosmic rays, and neutrinos. The search for dark matter from neutrinos is of particular importance since they are the only courier that can reach detectors from dark matter processes in dense environments, such as the core of the Sun or Earth, or from the edge of the observable Universe. I would like to introduce χarov, a software that bridges the dark sector and Standard Model by predicting neutrino fluxes from different celestial dark matter agglomerations. This package includes neutrino production coupled to a new calculation of electroweak corrections and neutrino propagation to observer's location.

Contributed 06 / 51

Event Generators for Accelerator-Based Neutrino Experiments

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In this talk I will summarize our recent Snowmass LOI. Upcoming accelerator-based neutrino experiments present a challenging theoretical problem for the event generator community. In our letter, we highlight some of the unique challenges and suggest some possible solutions. We believe that important lessons, both technical and organizational, can be learned from the great success of the hadronic event generator community at the LHC.

Contributed 08 / 52

Cosmological neutrinos and fundamental physics

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The physics surrounding neutrino mass and neutrino interactions presents key research opportunities in elementary particle physics, both in theory and in experiment. Paralleling the developments in those fields, advances in observational astrophysics and cosmology promise unprecedented precision in the measurement of cosmological quantities. In many cases, those quantities are shaped by how the physics of neutrinos plays out in the cauldron of the very early universe and its aftermath. Therefore, we anticipate complementary advances in both the fundamental physics of neutrinos and cosmology.

Contributed 08 / 53

From oscillation dip to oscillation valley in atmospheric neutrino experiments

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Atmospheric neutrino experiments can show the "oscillation dip" feature in data, due to their sensitivity over a large L/E range. In experiments that can distinguish between neutrinos and antineutrinos, like INO, oscillation dips can be observed in both these channels separately. We present a data-driven approach — that uses the asymmetry in the up and down events, binned in the reconstructed L/E of muons — to demonstrate the dip, thereby confirming the oscillation hypothesis. We further propose, for the first time, the identification of an "oscillation valley" in the $(E_\mu - \cos\theta_\mu)$ plane, feasible for detectors like INO having excellent muon energy and direction resolutions. We illustrate how this two-dimensional valley offers a clear visual representation and test of the L/E dependence, the alignment of the valley quantifying the atmospheric mass-squared difference.

Contributed 10 / **54**

Microscopic approaches to neutrino-nucleus interactions

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In this talk I will summarize our recent Snowmass LOI on "Microscopic approaches to neutrino-nucleus interactions". The advent of high precision measurements of neutrinos and their oscillations calls for precise theoretical calculations of neutrino scattering cross sections on target nuclei utilized in the detectors. Over the past decade, ab initio methods based on realistic nuclear interactions and current operators have been able to provide accurate description of lepton-nucleus scattering processes. Achieving a comprehensive description of the different reaction mechanisms active in the broad range of energies relevant for oscillation experiments requires the introduction of controlled approximations of the nuclear many-body models. I will give a short overview of recent developments in the description of electroweak interactions within different approaches, and discuss the future perspectives to support the experimental effort in this new precision era.

Contributed 08 / **56**

Dark matter neutrino interactions and implications for core-collapse supernovae

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We discuss the implications in a core-collapse supernova environment of a light dark matter particle that sees the standard model exclusively through its interaction with neutrinos. We consider the case of a light dark matter candidate which couples to neutrinos through a heavy mediator, and examine parameter regimes of interest from the point of view of supernova cooling, neutrino decoupling, and proto-neutron star heat transport.

Contributed 04 / **58**

Neutrino Quantum Kinetics in Supernovae

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Neutrino interactions with matter will set the neutrino luminosity, spectra, and duration of the neutrino signal from the next galactic core-collapse supernovae. Flavor oscillations will mix the signals from different neutrino species. The exciting prospect of fast flavor instabilities deep inside the supernova shock suggest that these processes occur at the same time and location, influencing each other in a nonlinear manner. I will discuss the importance of modeling these effects simultaneously and self-consistently, demonstrate current capabilities with simplified isotropic simulations, and outline the path forward to global simulations of the full explosion.

Contributed 10 / **59**

Nuclear transparency in Monte Carlo neutrino event generators

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The hadron cascade model is an essential part of Monte Carlo neutrino event generators that governs the final-state interactions of knocked-out nucleons and produced pions. Working in the context of NuWro, we show that such a model, enriched with physically motivated modifications of nucleon-nucleon cross sections and incorporation of nuclear correlation effects, can reproduce experimental nuclear transparency data. We estimate the uncertainty of nucleon final-state interaction effects and apply it to recent neutrino-nucleus cross section measurements that include an outgoing proton in the experimental signal. Finally, we draw conclusions on a perspective of identifying events that originate from the two-body current mechanism.

Contributed 06 / **60**

Radiative corrections in neutrino scattering

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Neutrino physics is reaching a percent level precision and account for radiative corrections is a necessary step in modern and future accelerator-based experiments. We introduce and calculate radiative corrections in neutrino physics. Firstly, neutrino-electron scattering provides a clean tool to constrain the neutrino flux. We provide the most precise up-to-date prediction for neutrino-electron scattering cross sections quantifying errors for the first time to be of order $0.2 - 0.4$ %. Secondly, neutrino-nucleon charged-current quasielastic scattering is one of the signal processes, the best tool for neutrino energy reconstruction, studies of the internal nucleon structure, and flux determinations. We study form factors and radiative corrections to this process.

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Neutrinos as Probes for Lorentz and CPT Symmetry

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The coming decade is poised to witness an abundance of measurements with the potential of substantial improvements of our understanding of neutrino physics. Many of these measurements can be harnessed for unprecedented studies of both Lorentz and CPT invariance, two closely intertwined cornerstones of established physics. These symmetries may nevertheless be violated in many theoretical approaches to underlying physics including ones involving departures from the ordinary classical spacetime structure. Within effective field theory, Lorentz and CPT breakdown is predicted to affect neutrino propagation, the kinematics of particle reactions involving neutrinos, and flavor oscillations including transformations between neutrinos and antineutrinos.

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Event Generators for Theory and Experiment

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The sensitivity of future neutrino experiments to oscillation parameters and BSM physics is highly dependent on the reduction of theoretical nuclear modeling systematics within the quasielastic regime. The usage of highly phenomenological or even classical nuclear models of Fermi motion, as well as nontrivial and inconsistent reweighting schemes, only adds to these woes. Also, many neutrino generators lack robust validation schemes on widely available electron scattering data to (partially) confirm their models of neutrino-nucleus interactions. Using GENIE, we have begun the interpolation and implementation of a new quantum-mechanically derived, inherently two-body, total inclusive quasielastic lepton scattering cross section. This model makes available much of the two-body semifinal state kinematics information at the scattering vertex via nuclear responses and two-body response densities. Currently, the electron—He-4 cross section has been validated across the available world quasielastic data and shows excellent agreement. Work is continuing on a GENIE generator module for this cross section and will soon output full final state topologies for study within detector geometries. The nature of this generator will make comparative study of two-body final states in past and current lepton scattering experiments fully realizable. The framework created for this generator can be utilized by similar future cross section calculations for larger nuclei such as C-12 and Ar-40.

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Assessing the accuracy of the GENIE event generator with electron-scattering data

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Precision neutrino oscillation experiments of the future—of which DUNE is a prime example—require reliable event generator tools. The 1–4 GeV energy regime, in which DUNE will operate, is marked by the transition from the low-energy nuclear physics domain to that of perturbative QCD, resulting in rich and highly complex physics. Given this complexity, it is important to establish a validation procedure capable of disentangling the physical processes and testing each of them individually. Discussing results from our recent paper [Phys. Rev. D 102, 053001 (2020)], we demonstrate the utility of this approach by benchmarking the GENIE generator, currently used by all Fermilab-based experiments, against a broad set of inclusive electron-scattering data. This comparison takes advantage of the fact that, while electron-nucleus and neutrino-nucleus processes share a lot of common physics, electron scattering gives one access to precisely known beam energies and scattering kinematics. Exploring the kinematic parameter range relevant to DUNE in this manner, we observe patterns of large discrepancies between the generator and data. These discrepancies are most prominent in the pion-producing regimes and are present not only in medium-sized nuclei, including argon, but also in deuterium and hydrogen targets, indicating mismodeled hadronic physics. We will discuss several directions for possible improvement.

For further details, see
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Underground probes of supernova mechanism

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The mechanism of the core-collapse supernova is not completely established and continues to fuel a lot of active research. With the advent of DUNE and HyperKamiokande, the neutrino burst from the next galactic core-collapse supernova will allow us to observe the development of the explosion in real time, during the first crucial ten seconds. The task is to understand how to read this signal, how to relate it to the underlying physical processes, and how to best optimize the detector design. In this talk, I will describe the neutrino signatures of the termination shock in the hot bubble region. I will show that it provides a sensitive probe of physical conditions above the surface of the protoneutron star.

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Interplay of Detection Opportunities for Neutrinos and Dark Matter

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We discuss how increased sensitivity in large direct detection experiments will allow to exploit them as effective neutrino detectors and probe neutrinos from different sources in complementary

regimes to conventional neutrino detectors. On the other hand, large neutrino telescopes like Super-Kamiokande provide favorable targets for dark matter from cosmic ray interactions and accelerated in cosmological environments.

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Axial form factor of the nucleon: implications for neutrino-nucleus cross section

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Knowing accurately the neutrino-nucleus cross section is of prime importance for extracting the neutrino properties from experimental data. In this endeavour, one crucial ingredient is the axial form factor of the nucleon.In this talk, we will discuss the implications of the recent lattice QCD results for neutrino-nucleus cross sections.

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Quasielastic interactions of monoenergetic kaon decay-at-rest neutrinos

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Monoenergetic muon neutrinos with an energy of 236 MeV are readily produced in intense medium-energy proton facilities at Fermilab and J-PARC when a positive kaon decays at rest ($K^+ \to \mu^+\nu_\mu$) in the beamline absorber.
These kaon decay-at-rest (KDAR) neutrinos offer a distinctive opportunity to study neutrino-nucleus interactions without having to deal with the complications raised by pion decay-in-flight neutrinos with broad energy-distributions.
These monoenergetic neutrinos carry the key to a better understanding of the role of e.g. initial and final-state interactions, and correlations in the nuclear medium, and they will help to reduce experimental and theoretical uncertainties and ambiguities in an unprecedented way.

The charged-current interaction KDAR muon neutrinos occur in a kinematic region that is strongly affected by nuclear effects such as Pauli-blocking and long-range correlations.
We present cross sections of electron- and neutrino-nucleus scattering in the kinematic region probed by KDAR neutrinos, paying special attention to the low-energy aspects of the scattering process.
Our model takes the description of the nucleus in a mean-field (MF) approach as the starting point, where we solve Hartree-Fock (HF) equations using a Skyrme (SkE2) nucleon-nucleon interaction.

We introduce long-range nuclear correlations by means of the continuum random phase approximation (CRPA) framework where we solve the RPA equations using a Green's function method in configuration space.
We discuss the relevance of a precise determination of KDAR ν_μ-nucleus cross sections for neutrino oscillation experiments. In particular for the MiniBooNE experiment that observes a large excess of electron-like events in a ν_μ beam in the (reconstructed) energy bins that overlap with the KDAR ν_μ energy.